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# NATIONAL MANPOWER INVENTORY FINAL REPORT,

Technical Appendixes .

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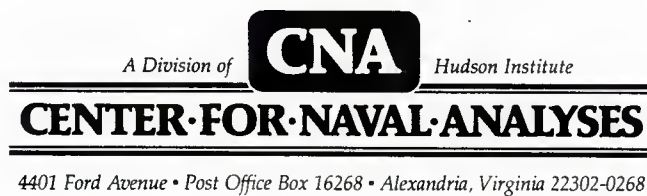
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# **NATIONAL MANPOWER INVENTORY FINAL REPORT**

## **Technical Appendixes**

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## ABSTRACT

This report on the National Manpower Inventory (NMI) is in three volumes. Volume I describes (1) the major inputs to the NMI and adjustments of the data made to meet NMI goals more directly; (2) the operational NMI model that was developed and its potential uses; and (3) some limitations inherent in the NMI data. Volume II provides technical documentation for the report, and Volume III is a user's guide to the software for the model.

## TABLE OF CONTENTS

	<u>Page</u>
Appendix A: Technical Difficulties With the MOS/Census Occupation Matches .....	A-1 – A-9
Appendix B: A Statistical Discussion of the Overcount Problem .....	B-1 – B-3
Appendix C: An Earlier Attempt To Count DOT Incumbents .....	C-1 – C-3
References .....	C-4
Appendix D: Technical Lessons From the NMI.....	D-1 – D-13
References .....	D-14
Appendix E: Examples of Instructional Codes Used by the National Center for Education Statistics .....	E-1 – E-6

**APPENDIX A**

**TECHNICAL DIFFICULTIES WITH THE MOS/CENSUS  
OCCUPATION MATCHES**

## APPENDIX A

### TECHNICAL DIFFICULTIES WITH THE MOS/CENSUS OCCUPATION MATCHES

A major problem in the development of the National Manpower Inventory (NMI) model centers on the existence of a substantial, uneven, and uncertain overcount of civilians with militarily relevant skills. The source of much of this problem is the necessity, given available data, to use several civilian occupational systems.

First, civilian jobs entailing skills relevant to the military are linked to specific military jobs, defined by the Military Occupational Specialty (MOS) taxonomy, through the use of the Fourth Edition of the *Dictionary of Occupational Titles* (DOT) codes. This was accomplished by the Office of the Assistant Secretary of Defense (Manpower, Installation, and Logistics) (OASD/MI&L).

However, the DOT system provides only job descriptions; there is no current information about the number of workers whose skills may be characterized by individual DOT codes. Therefore, a second set of linkages was used which linked DOT codes to 1980 Census occupational codes through the Standard Occupational Classification (SOC) system. The source for these matches was the National Occupational Information Coordinating Committee (NOICC) crosswalk.

Using DOT codes, the OASD/MI&L and the NOICC crosswalks were linked for the NMI, and counts of civilians with militarily relevant skills were identified by 1980 Census occupational codes.

In some cases, a single Census occupation may be defined by a large number of DOT codes, only a small fraction of which are militarily relevant (that is, have been linked to an MOS). In such a situation, the total number of incumbents in the Census job should be divided into those workers with militarily relevant skills and those without. The lack of information on



incumbents for DOTs, however, makes it impossible to determine the relative proportions of these two subpopulations.<sup>1</sup>

Some specific empirical results appear because of problems with the linkages themselves. That there might be such problems is not surprising since consistently classifying jobs into occupations within any single system is problematic, and crosswalks developed by both OASD/MI&L and NOICC are the results of considerable analytical and operational efforts to match across single systems. With the mechanical linkage of the two products (via their common DOT codes), any occasional error in either could multiply in the resulting CNA-constructed crosswalk.<sup>2</sup>

In brief, available data do not allow high precision in counting civilians with militarily relevant skills because one must move across systems with different occupational boundaries and aggregation levels. However, examination of the result of the MOS/DOT/SOC/Census methodology suggests four potential problem areas of which the user should be made aware. These are discussed in turn.

### **THE METHODOLOGY PRODUCES A SUBSTANTIAL AND UNEVEN OVERCOUNT OF CIVILIANS WITH MILITARILY RELEVANT SKILLS**

Under the crosswalk methodology, many DOT jobs can be, and are, matched to a single Census title. In itself, that is not a problem, as many workers do various kinds of work; moreover, many DOTs are narrowly

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1. See appendix C in this volume for discussion of an earlier attempt to dually code Third Edition DOT codes and 1970 Census occupational categories.

2. Both the OASD/MI&L and NOICC crosswalks used in this study represented basically new efforts. It seems reasonable that as more users—with diverse and specific research goals—scrutinize the linkages, refinements and revisions may already be underway. However, except for two specific cases documented in this appendix, the empirical estimates that result from the mechanically linked crosswalks have not been adjusted. This is because ad hoc “solutions” will vary among users and result in no approach or estimate that can be consistently reproduced by another user. Indeed, while one purpose of this volume is very specifically directed to documenting Volume I for technical users of the NMI, another is to suggest ways and means by which the data input to CNA software for manpower inventory could be improved.

defined. For most Census titles, however, the result is that only a fraction of the matched DOT titles have been determined to be of military relevance.

Differences in the historical roots and purposes of the two taxonomies lead to differences in occupational detail. For example, the Census system provides far more detail on types of postsecondary teachers than does the DOT, while the DOT classifications for operatives are far more precise than those of the Census. The result is that employment varies considerably by occupational title in both systems. However, while not precisely quantifiable, the DOT system results in many more titles that describe the jobs of fewer than, say, 25,000 or 50,000 of the roughly 100 million U.S. workers than does the Census.

Some insight into sources of the overcount problem can be gained by looking at the proportions of DOT titles within any Census occupation that were identified as being militarily relevant DOTs.

Table A-1 is an overview of the 472 Census occupations matched to DOT codes on the OASD/MI&L-NOICC crosswalk file. The third column describes those Census occupations identified as being militarily relevant. For 10.6 percent of those occupations, 90 percent or more of their NOICC-matched DOTs were shown as militarily relevant in the OASD/MI&L crosswalk. However, only 21 percent of the 259 Census titles have half or more of their associated DOTs flagged as being militarily relevant. In contrast to the apparently strong civilian-military fits identified in the top rows, over 40 percent of the matched Census occupations have less than 20 percent of their DOTs identified as militarily relevant.

As noted earlier, differences in these two civilian coding schemes make proportions of titles a very weak proxy for proportions of workers, but these distributions illustrate a source of both the overcount and its uneven distribution across occupations. Specifically, overcounts of skilled civilians will occur when incumbents of irrelevant DOT jobs are "pulled in" along with those of relevant DOT jobs via their matches to a Census occupation.

TABLE A-1

**CENSUS OCCUPATIONS MATCHED TO DOT CODES  
ON THE OASD / MI&L CROSSWALK FILE**

<u>Percent of DOTs in the Census occupation with military match</u>	<u>Percent of 472 Census occupations which have DOT equivalents</u>	<u>Percent of the 259 Census occupations identified by DOT match as militarily relevant</u>
90-100	5.7	10.6
80-89	.4	.8
70-79	1.5	2.7
60-69	1.7	3.1
50-59	2.1	3.9
40-49	5.3	9.8
30-39	6.8	12.5
20-29	8.5	15.3
10-19	10.4	18.8
any-9	12.3	22.4
0	45.1	N/A

The relative sizes of the different DOT occupational groups are unknown. However, according to a National Academy of Sciences' special committee review of the Fourth Edition of the DOT, there are:

indirect indications that the (DOT) coverage has been disproportionately concentrated in the manufacturing industries and that certain other industries, such as trade and services, are substantially under-represented.<sup>1</sup>

Moreover, the report found that "both the coverage of occupations and the quality of the descriptions proved to be very uneven."<sup>2</sup>

For NMI purposes, the DOT system's uneven coverage by sector appears to lead to the unevenness of the overcount. Table A-2 shows examples of

1. A.R. Miller, D.J. Trieman, P.S. Cain, R.A. Roos (eds.), *Work, Jobs, and Occupations: A Critical Review of the Dictionary of Occupational Titles* (Washington, D.C.: National Academy Press), 1980, pp. 9-10.

2. *Ibid.* p. 9.

Census occupations with large numbers of associated DOTs but only a trivial number of militarily relevant ones. Together, these six Census titles represent 4 million civilian workers, yet less than 1 percent of the actual job titles involved in the matches are defined as being militarily relevant. To count the civilians, as has been done, as persons able to "immediately apply those job skills to the performance of military occupations" (S.2248) is an overcount. To count them in proportion to militarily flagged DOTs, however, has no justification in the DOT methodology.

Appendix B in this volume details this problem in a probabilistic framework. Appendix D suggests another methodology for obtaining Census occupation job matches.

TABLE A-2  
SAMPLES OF CENCUS OCCUPATIONS WITH LARGE NUMBERS  
BUT NOT MILITARILY RELEVANT

Census code	DOTs		Census occupation	Number of incumbents (in thousands)
	Number of titles	Percent militarily relevant		
715	145	1	Misc. metal, plastic, stone, and glass-working machine operators	34
754	71	1	Packaging and filling machine operators	121
757	280	1	Separating, filtering, and clarifying machine operators	73
777	456	0.2	Misc. machine operators, n.e.c. <sup>a</sup>	699
785	692	0.4	Assemblers	1,700
889	382	1	Laborers, except construction	1,400

a. Not elsewhere classified.

## **THE METHODOLOGY ALLOWS MULTIPLE CIVILIAN MATCHES OF A SINGLE MILITARY JOB, WHICH CAN RESULT IN A LOSS OF JOB IDENTITY**

A distinct but smaller dimension of the overcount problem is the loss of job identity that can occur from the crosswalk and matching procedures. One result is that a single MOS may be described by several DOTs, which, in turn, may "walk" to several Census occupations. For example, the Navy Enlisted Ship's Serviceman (SH) rating (paygrades 4 to 6) matches into the following Census occupations (Census codes in parentheses):

- Sales workers, other commodities (274)
- Bookkeepers, accounting and auditing clerks (337)
- Stock and inventory clerks (365)
- Specified mechanics and repairers, n.e.c. (547)
- Dressmakers (666)
- Laundrying and dry-cleaning machine operators (748)

Fortunately, this problem is limited to a relatively small number of the MOSs (defined by paygrade as well as occupation) matched to Census occupations. Only 612 of the MOSs were matched to two or more Census titles and only 125 matched to three or more. The largest number of Census matches was for the Navy Hospital Corpsmen rating (E4-6); it matched to eight different Census occupational categories, including General Office Clerks, Statistical Clerks, Interviewers, as well as to occupations in the health care sector.

Because of the relatively small numbers, review of these cases by military job analysts may be a manageable task. The priority of such a task may depend on determination of the degree to which this problem is the key source of an overcount and the criticality of the MOSs involved.

## **THE LIST OF MILITARY OCCUPATIONS WITH NO CIVILIAN COUNTERPARTS IS NOT WHOLLY CREDIBLE**

Although divergent in context and methods, Census and military occupational systems have an important common element: their occupational schemes must solve, or at least address, the problem of accounting for all occupational incumbents. In contrast, DOT methods aim for an inventory of jobs,



and they do so by observing workers and soliciting descriptions from workers, supervisors, and professional organizations.<sup>1</sup>

One result of these methodological differences and the crosswalk procedures is that some MOSs that do have civilian counterparts are not identified by the crosswalk. In many cases, this appears to have occurred because their titles were not identified by DOT; in others, the cause is unclear. However, among MOSs with no apparent civilian counterparts at the DOT level (and, therefore, none in the Census) are the following:

Pictorial Editor  
ADP Systems Security Officer  
Biological Sciences Assistant  
Area Mail Router  
Staff Medical Officer  
Noise and Vibration Analyst

#### THE METHODOLOGY MISSES SOME MILITARILY RELEVANT CIVILIAN OCCUPATIONS

Seemingly unambiguous examples of Census occupations not identified as militarily relevant but which include incumbents with militarily relevant skills include the following:

Technical Writers (Census occupation 184)  
Almost all Postsecondary Teachers (Census occupations 113-159)  
Electrical and Electronic Technicians (Census occupation 213)  
Aircraft Engine Mechanics (Census occupation 508)

A complete list of Census occupations flagged, as appropriate, for matches to enlisted and/or officer occupations is found in appendix B of Volume I of this report.

The reasons the methodology misses these potentially relevant occupations vary. While most nonmatched occupations are probably true misfits,

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1. See Miller et al., *ibid.*, especially chapter 6, for a description and evaluation of these procedures in the Fourth Edition DOT.)

there is clearly the possibility of other false negatives, that is, other relevant Census occupations *not* flagged as matching militarily relevant specialties. Without review by military job specialists to correct this problem, the list above shows only the most apparent mismatch candidates. Because the last two occupations (Electrical and Electronic Technicians and Aircraft Engine Mechanics) appear clearly to be false negatives, however, the output of the OASD/MI&L and NOICC crosswalk was adjusted to correct this problem. Table A-3 lists the job descriptions Census coders use for classifying individuals into these occupations.

This adjustment was made by aggregating Census occupations. Specifically, Census occupation 515 (Aircraft Mechanics, excluding Engines) was merged with Census occupation 508 (Aircraft Engine Mechanics). This merger seemed justified because several military job titles that specified aircraft *engine* repair were found – after the crosswalk – in the Census occupation “Aircraft Mechanics excluding Engines.” (Apparently this particular problem was caused by the DOT taxonomy that lacks separate categories for airplane engine and nonengine mechanics. In this case, the Census taxonomy provides finer occupational specificity than the DOT taxonomy.)

Second, Census occupation 213 (Electrical and Electronic Technicians) was merged with Census occupation 523 (Electronic Repairers, Communications and Industrial Equipment). Again, this appeared to be a straightforward choice since Navy ETs (Electronic Technicians) were crosswalked to Census occupation 523.

TABLE A-3

## TITLES FOR CENSUS OCCUPATIONS 213 AND 508

213 Electrical and Electronic Technicians

Calibration-laboratory technician  
 Cameraman  
 Computer technician  
 Distribution planner  
 Distribution technician  
  
 Electrical engineering technician  
 Electrical technician  
 Engineering technician  
 Electrification advisor  
 Electronic-development technician  
  
 Electronic specialist  
 Electronic technician  
 Engineering technician  
 Instrumentation technician  
 Laboratory technician  
  
 Laboratory worker  
 Light technician  
 Lighting advisor  
 Lighting specialist  
 Research and development technician  
  
 Semiconductor-development technician  
 Stage technician  
 Telecommunications technician  
 Test-laboratory technician  
  
 Univac methods technician

508 Aircraft Engine Mechanics

Airframe technician, engine  
 Airplane tester  
 Apprentice  
     Airframe & power-plant mechanic  
     Airplane mechanic  
  
 Engine installer  
 Engineman  
 Experimental man  
 Magneto electrician  
 Mechanic  
  
 A and E  
 A and P  
 AC  
 Aircraft cylinder  
 Aircraft engine  
  
 Aircraft magneto  
 Aircraft  
 Airframe and power plant  
 Airplane  
 Dinkey engine  
  
 Engine, aircraft  
 Engine  
 Experimental, man  
 Helicopter  
  
 Jet  
 Missile  
 Motor, aircraft  
 Pre-flight  
 Propeller  
 Radiator  
  
 Rocket engine  
 Supercharger  
 Power-plant installer

Source: U.S. Department of Commerce, Bureau of the Census, *1980 Census of the Population, Classified Index of Industries and Occupations*, PHC80-R4, (Washington, D.C.: Government Printing Office), November 1982.



## **APPENDIX B**

### **A STATISTICAL DISCUSSION OF THE OVERCOUNT PROBLEM**

## APPENDIX B

### A STATISTICAL DISCUSSION OF THE OVERCOUNT PROBLEM

This appendix formulates the overcount problem described in appendix A in statistical terms. It defines more precisely the source and degree of the difficulties involved, and it concludes that the data currently available to the NMI project are insufficient to allow any technical solution to the problem. Additional data are required.

#### THE PROBLEM

The basic approach of the NMI model is to count civilians as having militarily relevant skills if their civilian job (as defined by Census occupations) crosswalks to a military job defined by Military Occupational Specialty (MOS). This crosswalk links the two classification schemes through the *Dictionary of Occupational Titles* (DOT). However, because a Census job may be characterized by multiple DOT codes, it is possible for a civilian to be counted in the total of incumbents in that Census job without having the skills (as defined by the DOT codes) that would, in fact, make his job militarily relevant. This is one source of a potential overcount of civilians with militarily relevant jobs.

Rather than dealing with absolute counts of civilians, the remainder of this discussion formulates the problem in terms of probabilities of certain events, which may be thought of simply as the proportion of civilians that satisfies the criteria defining the event. In addition, to simplify notation somewhat, it is assumed that the match between a single Census job and a single MOS is the main point of interest.

First, some events are defined:

<u>Event</u>	<u>Symbol</u>
A civilian chosen at random has the given Census job	C
A civilian chosen at random has a militarily relevant job skill	M
A civilian chosen at random has a job skill defined by a DOT code that crosswalks to the given MOS	D

The probability sought is that a randomly chosen civilian has the given Census job and has a skill appropriate for the given MOS. What is wanted is:

$$P(C \cap M) .$$

One approach to characterizing this probability directly parallels the existing crosswalk structure. In this approach,  $P(C \cap D)$  is calculated and the following is defined:

$$P(C \cap M) \equiv P(C \cap D) .$$

But,

$$P(C \cap D) = P(D/C)P(C) = P(C/D) P(D) .$$

$P(C)$  is simply the fraction of the civilian population in the given Census job.  $P(D/C)$  is the fraction of people in the Census job with the appropriate DOTs,  $P(D)$  the fraction of the entire population with the appropriate DOTs, and  $P(C/D)$  the fraction of that last subpopulation who have the given Census job.

$P(C)$  can be easily calculated. Further,  $P(C/D)$  is given by the ratio of the number of incumbents in the given Census job to the number of incumbents in all Census jobs that are crosswalked to the given MOS. Unfortunately, the complete lack of information on incumbents by DOT makes it impossible to calculate  $P(D/C)$  or  $P(D)$ . If either of these quantities could be calculated, the problem would be solved.

One possible approach to getting around this difficulty focuses on  $P(D)$ . The idea is to find some data set that would allow an estimate of the proportion of the civilian population with DOTs appropriate for the given MOS. In fact, this is the fundamental purpose of the entire project. Thus,  $P(D)$  appears to be a dead end.

The other possibility is  $P(D/C)$ . Calculating (or estimating) this probability requires the allocation of incumbents of the Census job among the various component DOT codes. There is no direct way of doing this. Nor does there appear to be an indirect approach, for example, relating demographic characteristics of active-duty military personnel to their MOS, which does not rely on the same sort of assumptions of an unwarranted equivalence of civilian and military job distributions. Only an arbitrary allocation seems left, and that is quite unsatisfactory.

## SUMMARY

In conclusion, the problem of overcounting civilians appears to be insolvable with the NMI database as it currently exists. The equating of relevant skills with DOT codes and the lack of a means of enumerating incumbents by DOT codes make it impossible to avoid the problem. Some means of estimating the overall distribution of DOT codes in the population or within each Census occupation is needed for the current approach to be successful. Failing that, the only rigorous solution to the problem appears to require a new crosswalk linking MOS codes with another occupational classification scheme that contains incumbent data as well as job descriptions.

**APPENDIX C**

**AN EARLIER ATTEMPT TO COUNT DOT INCUMBENTS**

## APPENDIX C

### AN EARLIER ATTEMPT TO COUNT DOT INCUMBENTS

#### THE APRIL 1971 CURRENT POPULATION SURVEY

Occupational reports of the 60,000 employed and experienced unemployed in the April 1971 Current Population Survey (CPS) were dually coded into the Third Edition of the *Dictionary of Occupational Titles* (DOT) and the 1970 Census classification schemes by specialists at the Department of Labor and the Bureau of the Census. Fourth Edition DOT codes were subsequently added by analytically converting Third Edition codes.<sup>1</sup> Thus, in conjunction with the DOT-1980 Census conversion on the National Occupational Information Coordinating Committee (NOICC) crosswalk, the CPS file theoretically allows the creation of a database containing detailed Census occupations weighted by the proportion of 1971 incumbents of DOT-level jobs.

Weighted data from the April 1971 CPS have been used in previous occupational research (e.g., Spenner, 1981; Temme, 1975; and Rumberger, 1981) focusing on trends or patterns in the occupational structure (e.g., changing skill level over time or patterns among DOT job characteristics and incumbent earnings or other characteristics). However, analytical goals of the users have never included actual employment estimates for individual Census occupations based on distributions of DOTs; nor has the timeliness of the estimates been a critical priority.

Nevertheless, the usefulness of these 1971 data for the NMI was investigated at an early stage, but it was decided that uncertainties surrounding estimates from this source outweighed the apparent advantages. The major uncertainties and shortcomings are summarized in the paragraphs that follow.

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1. For a more detailed description, see Roos and Treiman, 1980: 336-338.

## **Reliability of Monthly CPS Detailed Occupational Data**

The CPS has long been *the* major source of employment by occupational data between decennial censuses. However, neither the Bureau of Labor Statistics (BLS) (which sponsors the Current Population Survey) nor the Census Bureau (which conducts it) publishes detailed estimates from single monthly surveys for all individual occupations. In their view, the sample size has been (and remains) too small. (Compared with the 58,000 interviewed households in the current CPS, there were only 48,000 in April 1971 [U.S. Department of Labor, Bureau of Labor Statistics, February 1982: 196.] )

## **Representativeness of the Occupational Data**

In addition to the limitations on reliability just described, for about 12 percent of the 60,400 April CPS workers, dually coded information is missing (Spenner, 1980:245). Because occupation is the variable of interest, there seemed little basis for assuming that the distribution of the remaining 88 percent of workers is an unbiased sample.

## **Completeness of the Occupational Data**

Because of the considerable detail provided by the DOT and the relatively small size of the monthly CPS, only 4,500 of the more than 12,000 DOT titles occur among April 1971 CPS workers (Spenner, 1980:245). The NMI would therefore require other procedures for weighting incumbents with militarily relevant skills among the 8,000 DOT titles not represented in the CPS sample.

## **Age of the Occupational Data**

The data are for 1971. For NMI purposes, this raises two general concerns. First, the occupational mix has changed since 1971 (e.g., incumbents in computer and related "high-tech" fields have increased dramatically). Second, the occupational distribution of workers varies by age, and the labor force has become considerably younger since the dual coding was done. The proportion of the total force under age 35 was 42 percent in 1970 and 51 percent in 1980 (Fullerton and Tschetter, 1983: 5).

## **Compounding of Occupational Comparability Problems**

The April 1971 data required further translation through the crosswalk—via the Fourth Edition DOTs, from 1970 to 1980 Census occupational systems. The early empirical work suggested that, at the detailed occupational level, nontrivial numbers of matched cases appeared to be assigned to improbable outcomes.

These five sources of unreliability had to be considered together, and in light of the empirical estimates required by the NMI. They led to the alternative operational choice of using a single DOT match to flag a militarily relevant Census occupation.



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**APPENDIX D**

**TECHNICAL LESSONS FROM THE NMI**

## APPENDIX D

### TECHNICAL LESSONS FROM THE NMI

Experience with the National Manpower Inventory Model has suggested ways in which the matching of military and civilian jobs could be improved for use in mobilization supply analysis. This appendix focuses on some of the lessons suggested by the NMI work. Two assumptions are used. First, it is assumed that occupation is the appropriate measure of civilian skills for mobilization supply. On this point, the McFann-Gray report (May 1984:22) notes unusual unanimity among the functional specialists interviewed for the NMI project: "All individuals interviewed indicated the NMI had a use during mobilization and that occupation would be a useful means of identifying the skills of those acquired through mobilization."

The second assumption is that, for mobilization supply purposes, civilian data from household surveys (such as the Census or the Current Population Survey) are superior to those from establishment surveys (such as the Occupational Employment Service (OES) Survey) because of the demographic detail available on occupational incumbents in the former sources.<sup>1</sup> As the labor force ages in the coming decades, this is likely to assume increasing importance.

Potentially, there are many sources of data on the occupational and demographic characteristics of civilians. Such sources would include already-completed questionnaires or ongoing or wholly new surveys. However, because the Current Population Survey (CPS) conducted by the Census Bureau for the Bureau of Labor Statistics is the largest regular household survey, and probably best known, the CPS and the 1980 Census are generally used as references in the discussion that follows.

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1. For other purposes (e.g., for assessing civilian demand for specific military specialties), occupational employment as measured in the OES program may be superior. This is because the OES is measuring jobs rather than workers in jobs. Thus, the roughly 5 million civilians simultaneously working in two or more jobs are, in effect, "double counted" in the OES system. For estimating mobilization supply, such "double counting" is a nontrivial problem, but for assessing civilian occupational opportunities, it is an asset. As noted in the Final Report, however, the OES program may be the most promising source of data among currently available alternatives.

This appendix focuses on general issues in occupational classification and in comparability across classification systems, on crosswalk data available as input to the current NMI, and finally on procedures that would improve the reliability and flexibility of civilian input data and civilian-military links.

## OCCUPATIONAL CLASSIFICATION

An occupation is composed of many jobs, each of which consists of particular skills and responsibilities. At the operational level, that is not a simple definition. The very complexity of occupational classification and measurement gives rise to several sources of noncomparability among taxonomies. First, within any classification scheme, there is the problem of occupational boundaries; that is, what makes a particular collection of jobs sufficiently homogeneous to constitute an occupation? Similarly, why is another collection of jobs sufficiently different so as to constitute an occupation separable from that defined by the first set of jobs? In short, aggregating jobs into different occupations is never a wholly clear-cut task.

Second is the related question of what characteristic(s) will be used to define occupations. Different taxonomies can set different priorities for such characteristics. For example, type of skill, level of skill, supervisory responsibilities, place of work, as well as the work performed are among the characteristics considered in establishing principles of occupational classification.

Beyond the conceptual issues involved in the creation of an appropriate taxonomy, there are nontrivial problems of measurement. The very diversity of jobs pursued in the United States provides the key challenge: In the 1980 Census, more than 50,000 occupational pursuits were reported (Social Science Research Council, 1983:2); the Census scheme classified those reports into 503 occupations.

Given this unique diversity, it is not surprising that there are inevitable problems in matching two or more occupational coding systems. There are, for example, different levels of aggregation, or what Spenner (1980:254) called the "lack or misplacement of detail" between occupational systems. Spenner's research used the Dictionary of Occupational Titles (DOT) and Census data, and he noted that "several sources of error are intrinsic to using and moving between occupational classification systems." In addition to aggregation

differences, even for occupations with identical titles, nontrivial differences in job tasks may exist between taxonomies.

It is within this general context that data available for input into the current NMI should be assessed. Those data have thus far limited the NMI empirical work to indirect links that depend on matching *across* civilian occupational taxonomies as well as between military and civilian sectors. In all, three civilian taxonomies as well as DoD codes reflecting five military taxonomies provide the basic inputs. Such indirect links compound uncertainties in the resulting estimates of workers in the occupations of interest. Further, because the DOT codes were the critical link between the civilian and military sectors, precise numbers of militarily skilled incumbents within most of the detailed Census occupations are not known.

## THE NEED FOR A DIRECTLY MATCHED DATABASE

What is needed is a *direct* match between current military occupational specialties and occupations as they are pursued by civilians. For mobilization supply analysis, the database must contain demographic characteristics of workers in the occupations. Such a match can be achieved by directly double coding a sample of civilian occupational reports into both civilian and military classification systems.<sup>1</sup>

Under a double-coding procedure, job descriptions as provided in civilian household or person surveys would be coded routinely according to the current Census system by experts trained in occupational coding. Then, military specialists, working with the actual job descriptions as reported by civilian incumbents, would classify jobs according to the Integrated Defense Occupational System (IDOS) or other military taxonomy.

Both civilian and military occupational codes for each worker would be entered on computer tapes, along with age, sex, and other characteristics of workers. Such a project would allow direct estimates of civilian workers in occupational specialties of military interest.

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1. Note that, like Volume I of the NMI Final Report, this appendix is focusing on a database for research and planning, not a file through which specific individuals with specific skills would be identifiable.



For example, NMI empirical work to date shows that "many" civilian industrial engineers have militarily relevant skills. (Eleven of the twenty-two DOTs associated with that 1980 Census occupation were militarily relevant jobs.) However, as a hypothetical case, sample data directly coded into military and 1980 Census codes might show that 61 percent of those industrial engineers had militarily relevant skills and 35 percent of the total had both the appropriate skills and were under 40 years of age. Or, the directly coded data might show respective percentages of only 37 and 11 percent. Currently available data allow only an estimate of *all* civilian industrial engineers with specific age (or other demographic) characteristics. Whether any—or all—of them are among those with militarily relevant skills is unknown.

In addition to increasing the precision of estimates within the NMI model, dually coded occupational data could be applied to other civilian surveys allowing the imputation of codes identifying workers in specific occupations who had militarily relevant skills.<sup>1</sup> Since the new Standard Occupational Classification (SOC) system (to be described later) is being adopted by a growing number of government agency-sponsored surveys, such comparability across civilian surveys would greatly enhance the cost effectiveness of any double-coding effort.

As an independent effort or additional enhancement to double-coded data, literal reports of the actual occupation and industry should be carried as alphabetic descriptions on the computer file. While cumbersome in many ways, such descriptions obviously maximize available occupational detail. Because different mobilization scenarios impose different skill demands, verbal descriptions would allow subsequent users to more finely classify specialties as specific needs arose. Similarly, as modifications or additions are made to civilian or military taxonomies, alphabetic descriptions would allow reclassification of the affected cases without the need to return to the original questionnaires.

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1. The joint Social Science Research Council (SSRC) Census Subcommittee on Occupational Comparability (SSRC, 1983) has explored various imputation methods for achieving comparability over time in decennial Census occupation reports. Both explicit imputation models (e.g., linear and logit regression models) and implicit imputation models (e.g., the Census Bureau's "hot-deck" procedure) are under study. Despite the subcommittee's historical focus, their methodological work could be of great benefit to future NMI research.

The retention of alphabetic information has already been recommended for 1980 Census public-use sample files by the SSRC and the Bureau of the Census' jointly sponsored Subcommittee on Comparability of Occupational Measurement (described earlier). The interest of the Subcommittee is in comparability over time, but if their proposals for carrying alphabetics are accepted, actual costs of recoding civilian reports into military specialties would be reduced.

Before noting some considerations that might make a dually coded database more or less useful for mobilization analyses, the following summarizes the 1980 Census occupational classification approach and the questions used to solicit occupational information from household respondents.

## THE CENSUS CLASSIFICATION SYSTEM AND APPROACH

The occupational classification system introduced with the 1980 Census is a dramatic break from the previous system. The new 1980 Census taxonomy is based on the SOC system prepared by the Interagency Occupational Classification Committee of the former Office of Federal Statistical Policy and Standards. The intent of the SOC system is to establish a unified taxonomy for agencies to follow in the classification of civilian occupational information. First published in 1977, it was reorganized and revised in 1980, and the Census system is based on the 1980 SOC (U.S. Department of Commerce, Bureau of the Census, November 1980: iii).

The new SOC follows 12 principles for classification, the major one being the type of work performed (U.S. Dept. of Commerce, Bureau of the Census, November 1980: 8-9). Essentially, the SOC is based on a 4-digit coding system and classifies over 600 occupations. The structure of the classification has four levels: division, major group, minor group, and unit group; each grouping shows successively finer detail so that different levels of aggregation can be used easily.<sup>1</sup>

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1. One criticism of the new SOC system has been that some blue-collar occupational groupings "encompass a broad range of functionally related occupations, from highly skilled supervisors and craftsmen to unskilled helper positions" (Wool, 1979: 563). Directly coded data—particularly in conjunction with alphabetic descriptions—would allow refinements important for mobilization supply.

The lower panels in figure D-1 show the questions used to elicit job information in the 1980 Census, and the upper panel, in the on-going Current Population Survey (CPS). Responses to question 29a-b (23c-d) are the primary source of occupational coding, although both question 28 (23b) on industry and question 30 (23e) on class of worker are used in some of the coding decisions (see U.S. Dept. of Commerce, Bureau of the Census, July 1980:iv-vi). Respondents are the workers themselves or another household member serving as a "proxy" for workers in the household.

Using literal responses to these questions, specifically trained Census coders depend primarily on the *Alphabetical Index of Industries and Occupations* (U.S. Dept. of Commerce, Bureau of the Census, July 1980) which lists, in alphabetical order, some 20,000 industrial and 29,000 occupational titles. The occupational list is one developed over time, and, while titles for the 1980 Index were derived largely from previous editions and ongoing work of the Bureau, more than 6,000 new occupational titles were added for 1980. Many were from the DOT.

Unlike the DOT, the Census provides no descriptions of job duties for the 503 occupations in the 1980 taxonomy. Rather, the Bureau notes that each of the thousands of titles "can be considered a definition of their respective categories" (November, 1980: iii). By reviewing the *Classified Index of Industries and Occupations*, users can identify all of the individual titles that constitute each of the 503 detailed occupations in the 1980 system.

Although household (or person) surveys are the only current source of both occupational information and worker characteristics, they are not without error. Fortunately, sources of such error have been relatively well documented (e.g., U.S. Dept. of Commerce, Bureau of the Census, 1975, and February 1978; Hauser and Massaglik, 1982).<sup>1</sup>

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1. Because the establishment survey that collects occupational information is relatively new—the first, in 1971, was conducted in only 17 participating states (Goldstein, 1971)—less review and evaluation is publicly available to date for that alternative source of occupational information. However, some insights into problem areas in establishment surveys collecting employment information can be obtained from BLS research on industry employment (e.g., Utter, 1983: 154-157; Plewes, 1982). Like the CPS, the BLS establishment surveys depend on voluntary participation by respondents.



<b>23. DESCRIPTION OF JOB OR BUSINESS</b>
23A. For whom did . . . work? (Name of company, business, organization or other employer.)
23B. What kind of business or industry is this? (For example: TV and radio mfg., retail shoe store, State Labor Dept., farm.)
23C. What kind of work was . . . doing? (For example: electrical engineer, stock clerk, typist, farmer.)
23D. What were . . . 's most important activities or duties at this job? (For example: types, keeps account books, files, sells cars, operates printing press, finishes concrete.)

<p><b>28-30. Current or most recent job activity</b> Describe clearly this person's chief job activity or business last week. If this person had more than one job, describe the one at which this person worked the most hours. If this person had no job or business last week, give information for last job or business since 1975.</p> <p><b>28. Industry</b> a. For whom did this person work? If now on active duty in the Armed Forces, print "AF" and skip to question 31.  (Name of company, business, organization, or other employer)  b. What kind of business or industry was this? Describe the activity at location where employed.  (For example: Hospital, newspaper publishing, mail order house, auto engine manufacturing, breakfast cereal manufacturing) <input checked="" type="checkbox"/> c. Is this mainly — (Fill one circle)  <input type="radio"/> Manufacturing <input checked="" type="radio"/> Retail trade  <input type="radio"/> Wholesale trade <input type="radio"/> Other — (agriculture, construction, service, government, etc.)</p>	<p><b>29. Occupation</b> a. What kind of work was this person doing?  (For example: Registered nurse, personnel manager, supervisor of order department, gasoline engine assembler, grinder operator) b. What were this person's most important activities or duties?  (For example: Patient care, directing hiring policies, supervising order clerks, assembling engines, operating grinding mill)</p> <p><b>30. Was this person — (Fill one circle)</b>  Employee of private company, business, or individual, for wages, salary, or commissions . . . . <input checked="" type="radio"/>  Federal government employee . . . . . <input type="radio"/>  State government employee . . . . . <input type="radio"/>  Local government employee (city, county, etc.) . . . . <input type="radio"/>  Self-employed in own business, professional practice, or farm —  Own business not incorporated . . . . . <input type="radio"/>  Own business incorporated . . . . . <input type="radio"/>  Working without pay in family business or farm . . . . <input type="radio"/></p>
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**FIG. D-1: MAJOR QUESTIONS USED TO ELICIT OCCUPATIONAL INFORMATION, 1980 CENSUS AND 1983 CPS<sup>1</sup>**

1. Questions in the upper panel are from a facsimile of the Current Population Survey's standard form CPS-1. Questions in the lower panels are from the 1980 Census as presented in the *Classified Index* (U.S. Dept. of Commerce, Bureau of the Census, November, 1980).

First, the reliance on the reporting and coding of job titles — rather than occupational descriptions or definitions — has been identified as a source of imprecision and error. Second, "considerable response error" may also occur when information is obtained from proxy respondents rather than from workers themselves (Wool, 1979: 545). Third, response errors in the direction

of occupational upgrading appear to be a pattern in at least some occupations. For example, after identifying differences between (updated) 1970 Census data and National/State Industry Occupational Matrix System data collected from establishments, Swerdloff (1979: 574) reports that:

Some staff members at BLS believe that the difference in the estimates resulted, in large part, because the original census enumeration was inflated because individuals or members of their families who completed the census form described the person's occupation as carpenter, electrician, or some other skilled trade when, in fact, the individual was a helper or some other semi-skilled or unskilled worker.

To some degree, sources of possible error can only be identified. However, in other cases, adjustments can be made. For example, for some occupations—particularly the professions—researchers have restricted incumbent counts to only those cases also reporting specific levels of schooling. If literal job reports are available on data files, further specificity in identifying skilled subgroups will be possible.<sup>1</sup>

## A FEASIBILITY STUDY

For coding civilian occupational reports into military specialties, a key practical consideration is whether questions in figure D-1 elicit sufficient information to allow responses to be coded into military specialties. A test study would need to assess the feasibility of military coding of a sample of household survey reports.<sup>2</sup>

In addition to the question of whether sufficient information is provided, such a test would allow a more structured approach to the question of occupational transferability of skills. For example, the "kind of work" and "most important activities or duties" reported by a civilian worker will sometimes

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1. Because of the procedures designed to ensure the confidentiality of civilian reports, geographic identification is also potentially limited in household survey data. The impacts of such procedures on an NMI database would need to be explored.

2. It also seems possible that military researchers have explored such approaches for other projects.

describe a job that is very similar to, but a less-than-perfect match with, a particular military specialty. How "immediately" transferable must occupational skills be?

In considering this issue, the McFann-Gray report (1984, especially pp. 24-25) acknowledges that there is no simple solution and focuses on problematic matches that may occur among more equipment-oriented occupations. For illustrative purposes, however, the solution they suggest relates to the testing of individual recruits to identify particular skill deficiencies. In the context of a research database allowing national or subnational estimates of civilians with militarily relevant skills, their example is not directly appropriate, although results of a sample of such individual cases might be applied to refine estimates in particular occupations.

From a test study focusing on military coding of civilian household reports, more information would also be available to address the question of whether multiple classifications between civilian and military jobs would be allowed.<sup>1</sup> Clearly, skills do overlap between occupations. However, equally clearly, the NMI empirical work has shown that multiple matches can complicate subsequent analyses.

The CNA software module for dealing with false bottlenecks has been specifically designed to efficiently allocate civilians in occupations with multiple matches. (See Volume I of the NMI Final Report, pp. 81-90, and Volume III, Technical Documentation, pp. 13 and 14.) The creation of the module involved a nontrivial amount of analytical and operational effort, and this module would be available to the users of a dually coded database. The issue is, rather, the desirability of multiple codes compared with procedures allowing only a single principal match.

The paragraphs that follow present some considerations that might make a database containing dually coded occupational data and/or alphabetic occupational descriptions more useful for input into the NMI and mobilization supply analysis. Assuming that a feasibility test showed positive results, it would also provide information allowing considerations such as these to be addressed more precisely.

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1. Discrepancies between civilian and military coding decisions may also result. Procedures for determining how such cases would be resolved could also be tested.

## Sample Size and Design

To maximize the reliability of the estimates from dually coded data, a final sample needs to be large. As guidelines, two double-coding efforts by the Census Bureau to assess 1970-1980 classification changes might be noted.

The first, described by Rytina and Bianchi (1984), used a sample of 120,000 records from the 1970 Census which had been double coded into the 1970 and 1980 systems. They note:

And even though the sample of 120,000 is large, sampling variability becomes a problem when dealing with several hundred occupations. Our examination of the double-coded data for completeness shows that more than 90 percent of the 1970 and 1980 occupational codes are represented (p. 12).

Their interest was in employment by sex, and, in evaluating the double-coded data, they found that reliability in the proportion for females was lowest in small occupations. In their special sample, 312 of 441 occupations met their reliability standards. Those 312, however, accounted for 87 percent of the 1970 labor force.

The second effort—designed to enhance comparisons between CPS estimates before 1983 and from 1983 forward—involved double coding a 20-percent sample of CPS records in 6 months for 1981 and 1982. From the double-coded data, conversion factors were calculated to translate 1970 occupational codes to 1980 ones, and the factors were applied to 1982 CPS monthly data files. In their report, Green et al. (1983:13) limited their published 1982 data to a subset of occupational groups. Further, Rytina and Bianchi (1983:17) note that “the double-coded CPS data are not considered reliable at the detailed level when disaggregated by sex.”

For purposes of the NMI, what can be learned from these reports? First, “large” is very large in terms of a sample size that can sustain detailed occupational information and sex and age constraints. Because of this, at least two other considerations suggest themselves.

First, it might be useful to stratify a census or CPS sample by age before coding into military specialties. If, for example, mobilization scenarios would



rarely include workers over 30 or 40 years of age, a double-coded sample might most efficiently be based on only younger labor-force participants. Alternatively, reports of younger workers could simply be oversampled<sup>1</sup> if what is really desired are weighted distributions of young workers with militarily relevant skills.

Second, while possibly more operationally difficult to achieve, a sample stratified by occupation should be considered. If the number of incumbents was the key dimension for stratification, more reliable estimates of small occupations could be obtained by sampling those occupations disproportionately.

In addition, it should be noted that the military needs considerable detail on civilian skills, but there are obvious cases in which greater detail in civilian classifications is of little or no use to the military. For example, there are 5 detailed occupations in the Census "private household occupations" subgroup; 19 in "farm, forestry, and fishing"; and 62 in the "machine operations, assemblers, and inspectors" subgroup. The military probably has little use for many of these disaggregations.<sup>2</sup> If stratifying by occupational type or subgroup is feasible, some types of occupations could be undersampled.

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1. Such stratification could be accomplished using samples of completed questionnaires and/or by supplementing the sample in new rounds of current surveys. In the CPS context, for example, supplemental samples can be developed based on the characteristics of former CPS sample households to minimize sample selection and other survey costs (U.S. Dept. of Commerce, Bureau of the Census, January 1978: ch. 9). Because the ages of household members in previously interviewed CPS sample households have been identified, additional households with young members could be included in a special survey effort at relatively low cost.

2. For example, using the CNA file based on the OASD/MI&L-NOICC crosswalks, no DOTs matching Census occupations in the "private household" sector or in "farm, forestry, and fishing" were identified as militarily relevant, and only a handful were flagged in the "machine operators, assemblers, and inspectors" group. If coding decisions for major occupational groups require fewer resources than those required for classifications at the 3-digit level, some efficiencies in coding might be obtained by using current NMI input data as guidelines for collapsing certain of the detailed Census occupations.

## OTHER CONSIDERATIONS – SUPPLEMENTAL QUESTIONS

If the decision is made to double code a series of monthly CPS surveys (or other ongoing or future surveys), consideration might be given to supplementing the survey questionnaire with an additional question on current enrollment in educational or vocational training programs.<sup>1</sup> Such information would allow later users to substitute estimates of skills using Classification of Instructional Programs (CIPs) codes and student counts from Department of Education survey data. (See Volume I of this Final Report, pp. 29-38.)

For respondents who report recent military service, supplemental questions could obtain more specificity about when the veterans last served, since the current CPS records these dates only in broad categories. Analysts could statistically count recent veterans by their military specialties (as described in Volume I of this NMI Final Report, pp. 9-11) with more precision than would otherwise be available.

Although new questions might not be necessary, the survey should also ask about and code the jobs of current members of the Armed Forces. Those dually coded responses could considerably aid ongoing methodological research.

## CONCLUDING REMARKS

This discussion has focused on the Bureau of the Census – particularly the CPS – as a key source of a future database for mobilization supply research. Because many alternative potential data sources exist, there are some considerations – relating both to data quality and cost – that suggest the CPS might be a superior source.

First, the CPS is an ongoing survey that routinely collects all the essential information for an NMI database. That means, in turn, that established procedures and trained staff already exist for collecting and coding civilian

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1. In the CPS context, for example, the basic monthly administered CPS-1 instrument can be supplemented by additional inquiries. The Census Bureau's Technical Paper 40 (1978: 100-101) describes the general conditions under which the CPS facilities may be used for such purposes.

supply data. Thus, costs could be minimized without affecting data quality since a wholly independent data-collection effort would consume considerable resources.

Second, interviewers of the Bureau of the Census generally achieve higher interview response rates than other public or private survey research organizations. Because young people—and particularly young men—are generally more difficult to locate and interview than members of other demographic groups, this achievement is particularly important for an NMI database.

Third, because the CPS is conducted monthly—using standardized procedures—future updates to a dually coded database could be achieved with both greater confidence and less cost.

However, the creation of a research database containing military and civilian codes based upon direct reports of the jobs of U.S. workers would be a nontrivial undertaking for any organization selected to produce it. This is primarily because of the size of the necessary sample and because both interviewing and coding are labor-intensive efforts with their high associated costs. Nevertheless, a major lesson of the NMI at this stage is that indirect links between occupational systems—including the critical step through the key but unweighted DOT system—do not provide reliable occupation-specific estimates of workers with militarily relevant skills. Neither literal descriptions nor dually coded job reports would be error-free, but in conjunction with the NMI software, they would allow military planners the best possible empirical data from which to start.

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**APPENDIX E**

**EXAMPLES OF INSTRUCTIONAL CODES USED BY THE  
NATIONAL CENTER FOR EDUCATION STATISTICS**

## APPENDIX E

### EXAMPLES OF INSTRUCTIONAL CODES USED BY THE NATIONAL CENTER FOR EDUCATION STATISTICS

Both individuals in training and those who have completed training programs are potential mobilization assets; the National Center for Education Statistics (NCES) was consulted on the availability of current data describing those students in the higher education or training programs. NCES codes studies (enrollments and completions) by Classification of Instructional Programs (CIP) codes. To familiarize the user with the details available in these codes, this appendix provides samples of these codes for the 2-digit category, 47—Mechanics and Repairers, and the 4-digit and 6-digit subcategories under it. Also provided are samples of codes for two 4-digit and 6-digit subcategories under the 2-digit Engineering and Engineering Related category (15), 15.03—Electrical and Electronic Technologies and 15.04—Electromechanical Instrumentation and Maintenance Technologies.

- 47.0403 *Locksmithing and Safe Repair.* An instructional program that prepares individuals to repair and open locks, make keys, change lock and safe combinations, and install and repair safes.
- 47.0404 *Musical Instrument Repair.* An instructional program that prepares individuals to maintain, repair, and tune acoustic and electric musical instruments. Includes instruction in amplification systems of electric instruments, techniques of cleaning, and methods of tuning musical instruments.
- 47.0405 *Operation, Maintenance, and Repair of Audio-Visual Equipment.* An instructional program that prepares individuals to maintain and repair equipment designed to photograph illustrations and other copy that cannot be typeset, to develop negatives, and to prepare photosensitized metal plates for use in printing.
- 47.0406 *Shoe and Boot Repair.* An instructional program that prepares individuals to repair all types of footwear, including replacement and mending of worn or torn parts; repairing orthopedic footwear, refinishing and dyeing leather; and repairing other leather goods such as handbags, belts, and luggage.
- 47.0407 *Sporting Goods Equipment Repair.* An instructional program that prepares individuals to repair or replace faulty parts of sporting and athletic equipment such as fishing tackle, tennis rackets, golf equipment, and archery equipment. Includes instruction in regluing and rewinding shafts of bows and arrows; restringing tennis rackets; working with metal parts and using metal working tools; and researching specialized types of sporting and athletic equipment.
- 47.0408 *Watch Repair.* An instructional program that prepares individuals to make, maintain, and repair clocks, watches, chronometers, and other types of time-measuring devices by diagnosing malfunctions; disassembling, repairing, and/or replacing faulty parts; cleaning, assembling, and adjusting parts; and replacing straps, bands, crystals, crowns, and hands. Includes instruction in the use of various bench and hand tools such as lathes, staking tools, loupes, truing calipers, timing machines, pallet warmers, and other grinding, drilling, and polishing tools. Also instruction in the use of various materials such as metals, plastics, chemicals, oils, waxes, and abrasives.
- 47.0499 *Miscellaneous Mechanics and Repairers, Other.* Any instructional program in miscellaneous mechanics and repairers not described above.
- 47.05 *Stationary Energy Sources.* A group of instructional programs that prepare individuals to install, operate, and maintain large power sources for such purposes as generating electricity, pumping, and heating.
- 47.0501 *Stationary Energy Sources, General.* An instructional program that generally prepares individuals to install, operate, and maintain large power sources used for such purposes as generating electricity, pumping, and heating.
- 47.0502 *Conventional Electric Power Generation.* An instructional program that prepares individuals to install, operate, and maintain electric-power generating stations, and to operate and maintain gas, oil, and coal furnaces, boilers, and electric generators; steam, gas, or hydro-turbines; and diesel engines. Includes instruction in special instrumentation, controls, and emergency and safety procedures.
- 47.0503 *Industrial Nuclear Energy.* An instructional program that prepares individuals to construct, operate, and maintain reactor plants and industrial X-ray equipment; and use radioisotopes in industry for production and control operations.
- 47.0504 *Pumping Plants.* An instructional program that prepares individuals to install, operate, and maintain electric, diesel, or gas turbine-pumping installations that handle liquids, gases, or solids for delivery through pipelines or for local use. Includes instruction in the operation and maintenance of pipeline motors, engines, turbines, instruments, and controls.
- 47.0599 *Stationary Energy Sources, Other.* Any instructional program in stationary energy sources not described above.

- 47.06 *Vehicle and Mobile Equipment Mechanics and Repairers.* A group of instructional programs that prepare individuals to maintain and repair aircraft; automobiles; diesel engines in vehicles such as buses, ships, trucks, railroad locomotives, and construction equipment; stationary diesel engines in electrical generators; and small engines in mobile equipment such as lawnmowers and rotary tillers.
- 47.0601 *Vehicle and Mobile Equipment Mechanics and Repairers, General.* An instructional program that generally prepares individuals to maintain and repair aircraft; automobiles; diesel engines in vehicles such as buses, ships, trucks, railroad locomotives, and construction equipment; stationary diesel engines in electrical generators; and small engines in mobile equipment such as lawnmowers and rotary tillers.
- 47.0602 *Aircraft Mechanics.* An instructional program that prepares individuals to inspect, repair, service, and overhaul all airplane parts, including engines, propellers, instruments, airframes, fuel and oil tanks, control cables, and hydraulic units. This program is designed to meet Federal Aviation Administration requirements for licensing as an airframe/power-plant mechanic.
- 47.0603 *Automotive Body Repair.* An instructional program that prepares individuals to repair body and fenders of automobiles. Includes instruction in body preparation for painting and finishing.
- 47.0604 *Automotive Mechanics.* An instructional program that prepares individuals to engage in the servicing and maintenance of all types of automobiles. Includes instruction in the diagnosis of malfunctions in and repair of engines; fuel, electrical, cooling, and brake systems; and drive train and suspension systems. Also instruction is given in the adjustment and repair of individual components and systems such as radiators, transmissions, and carburetors.
- 47.0605 *Diesel Engine Mechanics.* An instructional program that prepares individuals to repair diesel engines in vehicles such as buses, ships, trucks, railroad locomotives, and construction equipment, and to repair stationary diesel engines in electrical generators and related equipment. Includes instruction in diagnosing malfunctions; disassembling engines and replacing parts; and in repairing and adjusting fuel-injection systems, oil and water pumps, generators, governors, auxiliary and accompanying power units, controls, and transmissions, using a variety of tools and testing and diagnostic equipment.
- 47.0606 *Small Engine Repair.* An instructional program that prepares individuals to maintain and repair small internal-combustion engines used on portable power equipment such as lawnmowers, chain saws, rotary tillers, motorcycles, and snowmobiles.
- 47.0699 *Vehicle and Mobile Equipment Mechanics and Repairers, Other.* Any instructional program in vehicle and mobile equipment mechanics and repairers not described above.
- 47.99 *Mechanics and Repairers, Other.* A group of instructional programs in mechanics and repairers not described above.
- 47.9999 *Mechanics and Repairers, Other.* Any instructional program in mechanics and repairers not described above.
- 15.03 *Electrical and Electronic Technologies.* A group of instructional programs that prepare individuals to support and assist electrical and electronic engineers, and other engineers and scientists concerned with the development of lasers. Programs stress specialized, practical knowledge related to the mechanical, mathematical, scientific, or technical aspects of electrical engineering, electronic engineering, and laser development.
- 15.0301 *Computer Technology.* An instructional program that prepares individuals to support engineers and scientists in the design, development, and testing of computer and peripheral devices. Includes instruction in electronic circuitry; prototype development and testing; systems design, selection, installation, and testing; solid state and microminiature circuitry to data storage devices, and the preparation of reports and documentation of test results.



- 15.0302** *Electrical Technology.* An instructional program that prepares individuals to support an electrical engineer in the design, development, and testing of electrical circuits, devices, and systems, for generating electricity and distributing electrical power. Includes instruction in model and prototype development and testing; systems analysis and integration, including design, development of corrective and preventive maintenance techniques; application of engineering data; and the preparation of reports and test results.
- 15.0303** *Electronic Technology.* An instructional program that prepares individuals to support the electronic engineer and other professionals in the design, development, modification, and testing of electronic circuits, devices, and systems. Includes instruction in practical circuit feasibility; prototype development and testing; systems analysis, including design, selection, installation, calibration, and testing; solid-state and microminiature circuits; and the application of engineering data to specific problems in the electronics field.
- 15.0304** *Laser Electro-Optic Technology.* An instructional program that prepares individuals to assist engineers, scientists, or plant managers in the assembly, installation, testing, adjustment, and operation of various types of lasers for various applications. Includes instruction in safety precautions and the optical, physical, and chemical theory and application of each laser device.
- 15.0399** *Electrical and Electronic Technologies, Other.* Any instructional program in electrical and electronic technologies not described above.
- 15.04** *Electromechanical Instrumentation and Maintenance Technologies.* A group of instructional programs that prepare individuals either to support or assist mechanical and electrical engineers, or to install and service electromechanical equipment. Programs stress specialized, practical knowledge related to the mechanical, mathematical, scientific, or technical aspects of mechanical and electrical engineering, biomedical engineering, computer science, and instrumentation design.
- 15.0401** *Biomedical Equipment Technology.* An instructional program that prepares individuals to manufacture, install, calibrate, operate, and maintain sophisticated life-support equipment found in hospitals, medical centers, and research laboratories. Includes instruction in the use of testing and diagnostic instruments; calibrating techniques; potential hazards and safety precautions; and methods of installation, repair, maintenance, and operation of the equipment.
- 15.0402** *Computer Servicing Technology.* An instructional program that prepares individuals to install, program, operate, maintain, service, and diagnose operational problems in computer systems arising from mechanical or electrical malfunctions in computer units or systems. Includes instruction in the underlying physical sciences and supporting mathematics of computer design, installation, construction, programming, operation, maintenance, and functional diagnosis, and how to detect, isolate, and correct malfunctions. Programs describe the electrical and electronic circuits and mechanical devices used in computer construction and their combination into systems in individual computers or computing installations, as well as instruments used to detect weaknesses or failures in electrical systems in computers.
- 15.0403** *Electromechanical Technology.* An instructional program that prepares individuals to assist mechanical and electrical engineers and other managers in the design, development, and testing of electromechanical devices and systems such as plant automation, automated control systems, servomechanisms, vending machines, elevator controls, missile controls, tape-control machines, and auxiliary computer equipment. Includes instruction in assisting with feasibility testing of engineering concepts; systems analysis (including design, selection, testing, and application of engineering data); and the preparation of written reports and test results.
- 15.0404** *Instrumentation Technology.* An instructional program that prepares individuals to design, develop prototypes for, test, and evaluate control or measurement devices on systems, and to prepare graphs, written reports, and test results in support of the professional personnel working in the field of instrumentation. Includes instruction in the fields of electricity, electronics, mechanics, pneumatics, and hydraulics as they pertain to the principles of control, recording systems, automated devices, and the calibration of instrumentation units or systems.
- 15.0499** *Electromechanical Instrumentation and Maintenance Technologies, Other.* Any instructional program in electromechanical instrumentation and maintenance technologies not described above.



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